REPORT

OF

GENERAL CHARLES K. GRAHAM,

ENGINEER-IN-CHIEF OF THE

DEPARTMENT OF DOCKS,

FOR THE

YEAR TERMINATING APRIL 30, 1875

TOGETHER WITH

ADDENDA

RELATED SUBSEQUENT TO HIS RESIGNATION OF THAT POSITION

NEW YORK:
MARTIN B. BROWN, PRINTER AND STATIONER,
No. 201, 203 & 205 William Street.

1875.

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NEW YORK, June 1, 1875.

EUGENE T. LYNCH, Esq.,
Secretary of the Board of Docks:

SIR—I have the honor to submit for the consideration of the Board of Commissioners governing this Department the following report of the several works under my supervision during the year ending April 30, 1875.

Before giving an account of the work performed on the different sections during the year, it has seemed advisable, in order that the Commissioners may have before them the means of arriving at a proper understanding of what has been accomplished, that each separate work should be described from its inception.

NEW PIER NO. 1, NORTH RIVER.

This pier, which starts from the bulkhead wall at the Battery, at a distance of about 82 feet north of the north point of tangency of the curve of the wall, was designed by my predecessor, General McClellan, to be 500 feet in length by 80 feet in width, giving, consequently, an area of 40,000 square feet. Its design is that of a series of semicircular arches, the first springing from the bulkhead wall, faced on the sides with cut granite, and formed inside with concrete. These arches rest on beton blocks, which are supported by masses of concrete contained in wooden cribs, resting on the bed rock.

The work of laying the foundations of sub-piers Nos. 1, 2, and 3 was begun in the early part of the autumn of 1872, and these and the superstructure of three arches were completed prior to my appointment in July, 1873.

The nature of the bottom for the first sub-pier, and the short distance at which it was constructed from the rip-rap foundation forming the base of the bulkhead wall, rendered the use of a crib, such as employed for the foundations of the other sub-piers, impossible. The following method was, therefore, adopted :

The dock silt was first dredged as close to the above-mentioned rip-rap foundation as was deemed safe, but, with all the precautions taken, it was with extreme difficulty that enough could be excavated to give a proper bearing to the necessary sub-foundation. Broken stone was then placed on the site, and this was pounded down with an iron rammer fastened to the end of an oaken pile, worked in the ways of a pile-driver. A wall of dimension stone was then built up, in a series of headers and stretchers, at a fixed distance from the line of bulkhead, and at a depth of about thirty feet from mean low water. Inside of this wall more dimension stone was placed, irregularly, and the interstices filled up with broken stones. Concrete blocks were then placed, holding iron stanchions, so constructed that guide-planks were lowered and fixed in them, movable at will to a given level below mean low water, and fastened in place by iron pins. The dimension stone wall was then closed at either end, broken stone placed, where necessary, and a trough or basin formed for the reception of the concrete in mass forming the base upon which the beton blocks, which carried the sub-pier up to the springer blocks, firmly rested.

The concrete was mixed on scows and lowered into the trough by means of a sloop rigged with a derrick-boom in the usual manner. It was dumped by divers, and, when brought up to the required "formation level," was smoothly leveled by means of a heavy iron "straight-edge," resting on the guide planks. In this manner a hard and even bed was

prepared to receive the beton blocks to be described hereafter.

In preparing the second sub-foundation, a crib was used of 84 feet in length by about 13 feet outside width, firmly braced and bolted together, and weighted with rip-rap stone placed in bins on the sides, spuds for regulating the lowering of material running through iron brackets on either side at regular intervals. The 100-ton derrick held this structure while it was being weighted, and then placed it in position on the bottom. In this crib a canvas bag was firmly fastened to the bottom, and this, when lowered, formed a basin for the reception of the mass concrete, which was then deposited, built up, and leveled in a similar manner to that employed in Sub-pier No. 1. The third and all subsequent foundations were made by means of a similar crib, the width varying somewhat, but instead of canvas bags, secured to the bottom, planking was used, whenever necessary, and fastened in place by divers. The use of long spuds was likewise discarded. Upon the foundations prepared in the manner thus described, base blocks of concrete made in moulds and weighing about 26 tons each, were lowered into position by the large derrick, and, when the alignment was perfected, pier-blocks, varying in height according to circumstances, were placed upon the base-blocks, these pier-blocks being so made as to allow a "berme" of 18 inches on either side.

On these pier-blocks the "springers" were placed, granite on the outside and concrete within; centres were set, and the necessary arching and spandrel-walls proceeded with. The hearting and deck of the pier, throughout, have been formed of pounded concrete, with occasional rip-rap in the hearting.

This system of construction has been generally adhered to, since my incumbency in office, and arches Nos. 5, 6, 7, 8, 9, and 10 have been completed. I had contemplated the idea of employing a wall of "pierre perdue" in place of cribs, having used it successfully in the construction of 84 feet of wall to the northward of this pier, after my appoint-

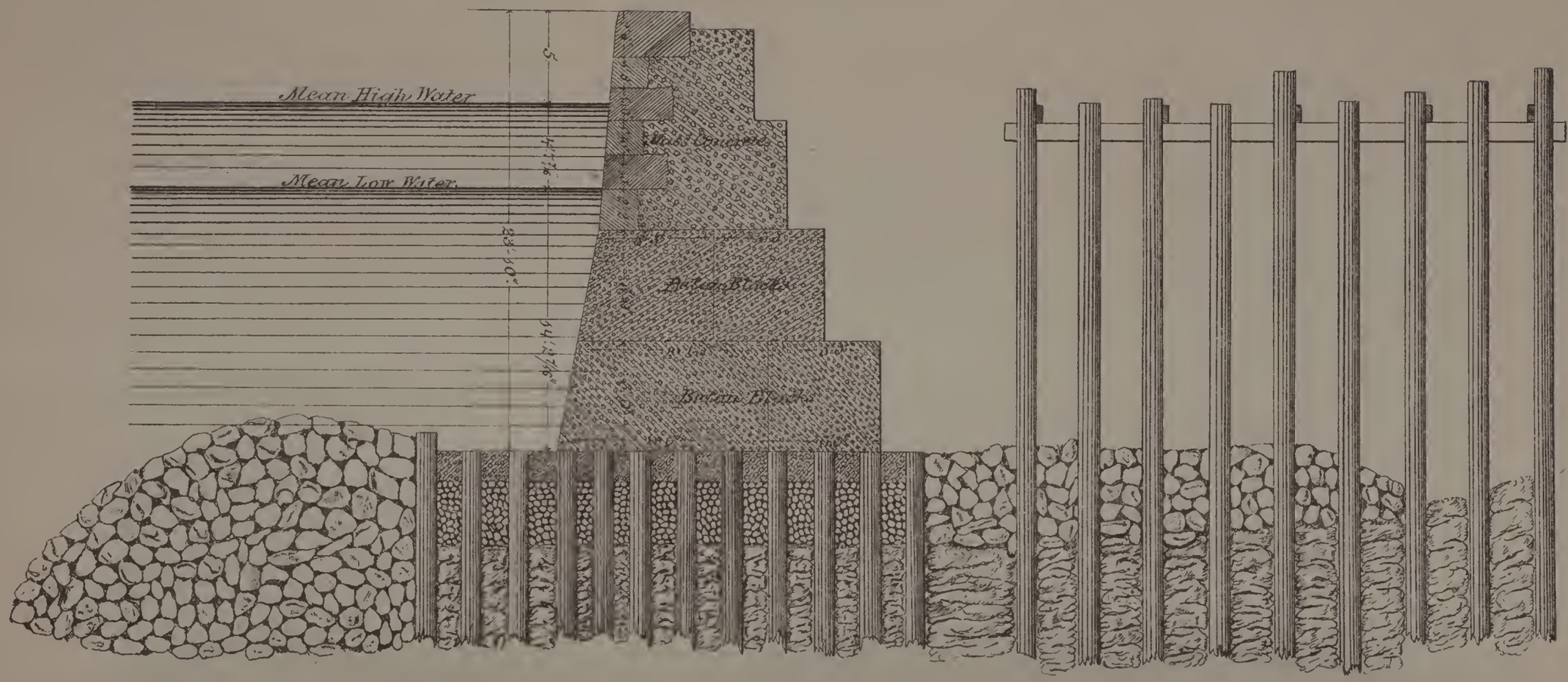
ment, my intention being to carry this stone wall along the whole extent of the pier and to weight it with three times the amount which it was intended to carry in any probable use.

To keep it weighted for a period of three or four months, then to remove the weighting and to fill the interstices with smaller stones ; upon this laying six inches of concrete, and on that placing the base and pier-blocks for the several arches. I am satisfied that this method, giving, as it would have done, a uniform foundation level, would have been more economical and quite as successful as the present system, but, after having made a commencement, I desisted for reasons which it is not necessary to mention, and followed the plan above stated, as inaugurated by General McClellan.

It is but just to say that the plans for this work were prepared by Mr. Isaac Newton, engineer in charge, who supervised its construction until a brief period before my appointment, General McClellan having the most unlimited confidence in his integrity and ability. Mr. Newton also designed and supervised the construction of the large derrick, which was employed so successfully in laying the beton blocks at the Battery, and at the Christopher street section.

The Christopher Street Section.

When the Board of Commissioners, by a resolution adopted September 26, 1873, ordered a section of the river-wall to be commenced at Christopher street, that part of the water front extending from Barrow street to Perry street was occupied by four piers and the old Hoboken Ferry platform, having an aggregate area of 77,460 square feet, and yielding to the city a revenue of $22,775 per annum. Piers Nos. 51, 52, and 53, originally built in the old style of blocks and bridges many years since, had been widened and extended as the demand for wharfage facilities in that part of the town increased, without any system or plan, except that of satisfying the call of some steamboat or barge owner for accommodation.



Section of Wall.

Christopher Street, N. R.

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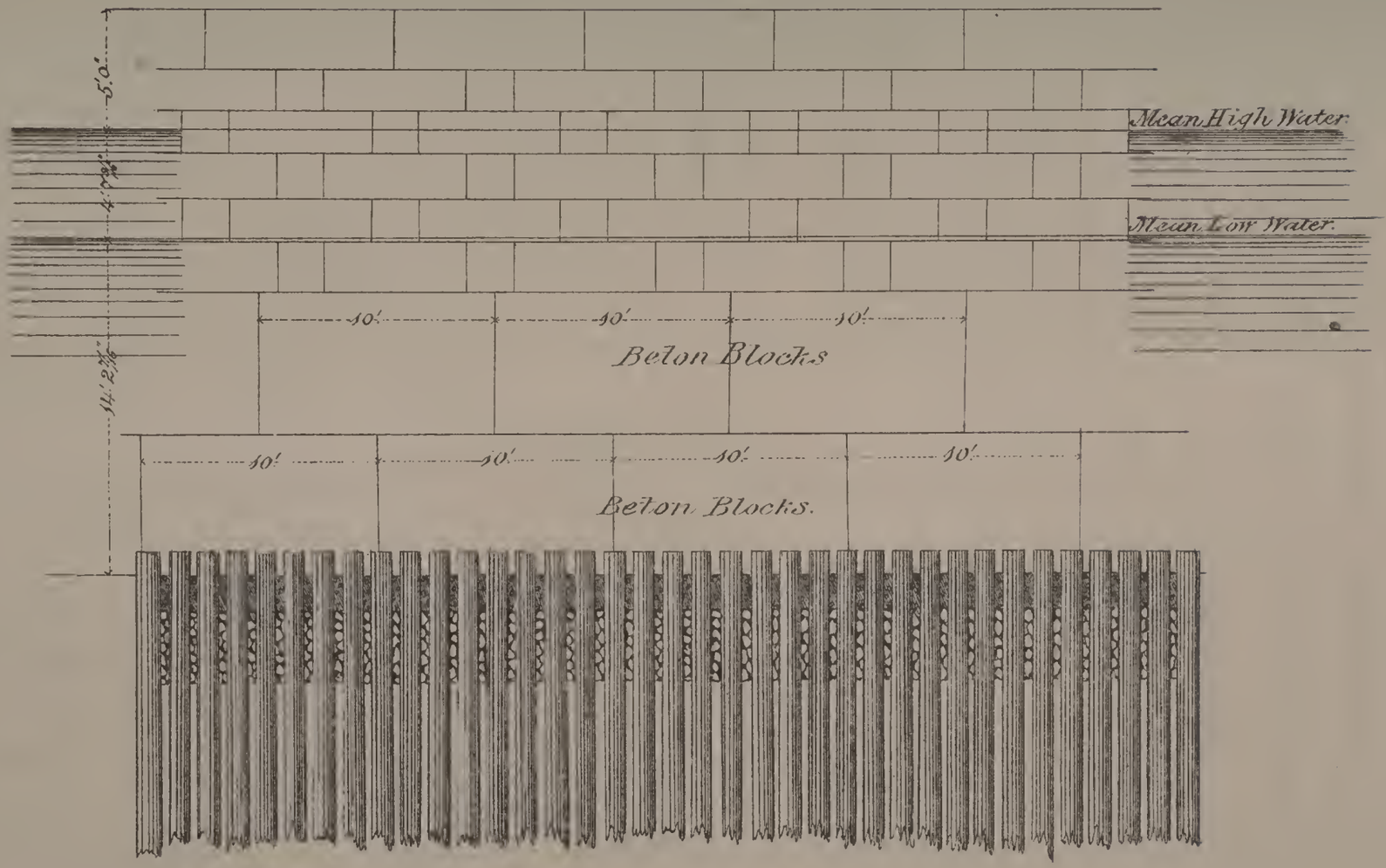


Elevation of Wall.

Christopher Street, N.R.

American Photo-Lithographic Co. N.Y. (Osborne's Process.)

Four hundred and nine feet of the bulkhead, from Pier No. 51, north, were occupied by oyster scows, around which the filth of the sewers had accumulated until, at low water, the bottom, near the bulkhead, was exposed, and, at a distance of 160 feet from the bulkhead, there was a depth of water varying from only 4 to 6 feet.

On the 30th of September, 1873, dredging was commenced between Piers Nos. 51 and 52, to make a trench averaging 80 feet in width, having a mean depth of 20 feet below low water, and continued north and south until it reached a length of 1,300 feet. This work was carried on in close proximity to vessels coming in or going out, discharging and taking in freight, and to which the right of way was always given, adding much to the cost of the work. The amount of dredging done on the section, to April 30, 1875, was, in the slips, 29,450 cubic yards; for the bulkhead, 45,615 cubic yards; making a total of 75,065 cubic yards.

To give the public the use of the piers beyond the established bulkhead line, a temporary bridge was built, 30x254 feet, from the foot of Christopher street, along the north side of the ferry slip to the south L on Pier No. 51 (October 14 to November 6, 1873), and another (November 11 to December 4, 1873), from the north L of Pier No. 51 to Pier No. 52, 50 feet wide by 138 feet long.

As soon as the connections were completed, giving a roadway to Piers Nos. 51 and 52, these piers were cut away in the line of the wall.

To provide for the accommodation of the oyster scows between Piers Nos. 51 and 52, on the 28th of October the work of tearing up old Pier No. 53 was commenced, and was continued until a sufficient depth of water was obtained near the bulkhead to float the scows, and, on the 27th of November, they were moved into their present quarters.

In front of Pier No. 53 there was then lying, in the mud, the wreck of an old dry dock, with a sunken canal boat on what had once been the ways. This dock, after passing chains under the bottom, was lifted from its bed with the

large steam derrick, and carried away and beached at Fifty-seventh street, North river.

Shortly after commencing the dredging for the river-wall foundation, orders were received to begin the construction of new Piers Nos. 44, 45, and 46, and work was commenced on them December 11, 1873, as follows: On Pier No. 44, at a point about 75 feet west of the bulkhead line; December 16, on Pier No. 45, at a point 80 feet from the bulkhead line, a connection having been built north from old Pier No. 52, 30 by 100 feet; on the 27th of December, Pier No. 46, at a point about 86 feet west of the bulkhead line.

On the 31st of March, 1874, the work of building the new ferry platform was begun, at a point 25 feet west of the bulkhead line; and the driving of piles for new Pier No. 43 was commenced on the 22d of April following. When the construction of these new works was decided upon, old Piers Nos. 51 and 52 were taken away, in portions, from time to time, as they interfered with the progress of the work, until the latter part of March, when they were entirely removed. By the 30th of April the new piers had advanced towards completion, as follows: Pier No. 43, ⅛; the Hoboken Ferry platform, ¾; Piers Nos. 44 and 45, about ⅛; and Pier No. 46, ¾.

The work of driving piles for the foundation of the river wall was begun January 2, 1874, at a point five feet north of the north side of new Pier No. 44, and by the 30th of April there had been driven 2,603 piles. February 18, began cutting off these piles, at 14.21 feet below mean low water, and by the 30th of April there had been cut off 1,826.

March 25, commenced putting down 4-inch stone between the piles cut off, and by April 30 there had been put down 804 cubic yards. On the 13th of April the concreting between the pileheads was begun, and by April 30 this work had extended over an area of 27½ by 140 feet. By the same date there had been placed, in front and rear of the wall, 600 cubic yards of rip-rap stone.

Thus, on the 30th of April, 1874, work was being prosecuted with vigor on the river wall, on the ferry platform, and

on four new piers, 241 men appearing on the Department pay-rolls at the Christopher street section. The assistant superintendents and foremen were all capable men who, having great interest in their work, took advantage of all means in their power to carry out my plans.

The bulkhead wall at this section, 23 feet 10 inches in height, is built on a foundation of piles, cut off 14 feet $2\frac{7}{16}$ inches below mean low water, filled around the heads with broken stone and concrete, thus making a solid level platform, on which were placed two courses of beton blocks, each 6 feet high. On the top of these blocks rests a facing of granite masonry, backed with mass concrete, for a height of 9 feet 4 inches, or up to the coping, which, for the present, has been simply backed with earth filling, the coping, with a rise of 2 feet 6 inches, having been left out in the wake of the piers. The lower 12 feet of the wall has a batter of $2\frac{1}{4}$ inches to the foot, and the granite facing a batter of one inch to the foot.

When the mud had been dredged out, in the line of the wall, to a depth of 20 feet below low water, piles, varying in length from 50 to 76 feet, with the character of the bottom, were driven until they gave an absolute refusal or would not go down more than $1\frac{1}{2}$ to 2 inches, with 15 feet fall of a 1,700 pound hammer. The bottom changes from the foot of Christopher street, with gravel and sand at a depth of 44 feet below low water, the gravel and sand generally sinking towards the foot of West Eleventh street, where only a moderately tenacious clay was found at a depth of 100 feet. The piles were spaced $2\frac{1}{2}$ feet between centres, north and south and across the wall, except three piles in the row near the toe of the wall, which were placed two feet apart between centres. The wall being $17\frac{1}{2}$ feet wide at the base, the pile foundation extends beyond it $7\frac{1}{2}$ feet in front and $2\frac{1}{2}$ feet in rear, making the foundation $27\frac{1}{2}$ feet wide.

These piles were cut off by a circular saw attached to a sliding frame in the ways of a pile-driver, at a distance of 14 feet $2\frac{7}{16}$ inches below mean low water, and, between their

heads, stones of about 4 inches cube were thrown from the deck of a scow, for a depth of from 2 to 6 feet and up to within 1 or 2 feet of the formation level. This foundation stone did not have the uniform depth of 6 feet, because such a mass of liquid mud had flowed from all directions into the trench, during the time intervening between the driving and the cutting off of the piles.

On the stone thus arranged, and for the purpose of binding the piles together, concrete was placed, made in the proportions, one part cement, two parts sand, and three parts broken stone, for a depth of from 1 to 2 feet. This concrete was put down by the aid of divers, at first through a tremie 12 inches square inside, made of 2-inch pine planks, a mode which, although expeditious, was soon abandoned on account of the washing of the cement, and was replaced by the ordinary triangular bucket, lowered by a hand-winch from the deck of a scow.

On the foundation thus prepared, beton blocks, manufactured at the Gansevoort street yard, were lowered by the hundred-ton derrick, and placed accurately in position with the aid of divers. These blocks are in two courses, each course consisting of two lines of blocks, front and back, of the following dimensions :

	DIMENSIONS.	CONTENTS.	WEIGHT.
1st Course—Front.....	11′ 6″ and 10′ 4½″ × 10′ × 6′	24.3 c. y'ds.	45.5 tons
2d " "	7′ 4½″ and 6′ 3′ × 10′ × 6′	15.13 "	28.3 "
1st & 2d Course—Back..	6′ × 10′ × 6′	13.3 "	24. "

The wall having been in this manner brought up to within 2 feet $2\frac{7}{16}$ inches of mean low water, the first course of granite, with an average rise of 2 feet 1 inch, was laid. At the same time, at the back of the blocks and within two feet of the edge, was placed a mould-board, of 2-inch spruce, to retain the concrete backing. This mould-board was made with a foot and temporarily secured in position by weighting.

Between the first course of granite and the mould-board mass concrete was lowered in triangular tubs, in the propor-

tions of one part cement, two parts sand, and four parts broken stone, until the top of the granite was reached, when the second course of granite was laid and backed in the same manner. The latter being above water at some stages of the tide, the concrete was made with a larger proportion of stone (1, 2, and 5), and packed down with rammers.

When the top of the third course of granite was reached, bringing the wall up 5 feet 10 inches from the beton blocks, the mould-boards were set in towards the face of the wall two feet, thus reducing the thickness at the top of the course next the coping to 7 feet 4 inches.

At this point the coping was laid between the piers, in pieces 8 feet long, with a rise of 2 feet 6 inches, and a width of 4 feet, and in the wake of the piers a rubble wall, 3 feet 3 inches wide by 18 inches high was built, to protect the timber of the piers from contact with the earth filling.

To prevent any lateral movement of the wall as the work of laying the beton blocks advanced, rip-rap stone was thrown in the front and rear over a width of 25 or 30 feet, until it came up to within an average distance of 10 feet from low water in front of the wall, and up to the formation level in the rear. This rip-rap has an average depth of 6.7 feet.

In the rear of the wall seven rows of piles were driven, 4 feet between centres, to serve as supports for railways and platforms for the reception of filling, if brought in large quantities, and for the support of platforms if the filling should be delivered in carts, the main object, however, being to relieve the wall from the severe lateral pressure it would experience when the large amount of filling, rendered necessary by the excessive depth and extreme tenuity of the silt, should be put in, the intention being to dump on both sides of the platform, the exterior filling to bring a gradually increasing pressure against the wall; and the filling inwards, which was designed to be in the ratio of 2 to 1, to force the mud towards the old bulkhead line, so that it might be gradually surrounded and its power overcome. These piles formed nuclei, around which the earth collected, at an angle of

about 75°, thus increasing the ordinary angle of slope, which may be taken as about 25°, so that the lateral pressure against the wall was immensely diminished.

The work done on the Christopher street section during the year ending April 30, 1875, was as follows :

Dredging for the river wall, cubic yards	30,950
" slips and oyster basin, cubic yards	104,022
Total, cubic yards	134,972
Piles driven on 694 feet on foundation	3,625
" in the rear of the wall	1,186
Piles cut off at the formation level	4,349
Length of formation concreted, feet	975
Beton blocks laid, May 5 to December 23	438
438 Beton blocks contained, cubic yards	7,234.6
Length of wall laid at the base blocks, feet	1,115
" granite facing, 9 feet 4 inches high, feet	1,080
" " coping, feet	524.5
Quantity of granite (reported by Assistant Engineer Maclay), cubic feet	30,476.5
Rip-rap stone in front and rear of wall, cubic yards	10,005
Four-inch stone on the foundation, cubic yards	1,791
Concrete stone in foundation and wall, cubic yards	3,947
Sand for concrete and mortar, cubic yards	1,920
Cement, concrete, and mortar, barrels	6,312

New Pier No. 43 was entirely constructed, with the exception of 81 piles driven before May 1, 1874.

The Hoboken Ferry platform—area 27,166 square feet, was finished, three-fourths of it having been constructed before May 1, 1874.

New Piers Nos. 44 and 45 were completed and connected with the wall.

Of new Pier No. 46, the outer and inner ends were built and the inner end connected with the wall.

New Pier No. 47, 50x215 feet, was built, 75 feet of the outer end being supported by 36 columns.

A platform, having an area of 27,210 square feet, and 475 feet long, on the eastern side, was constructed to connect new Piers Nos. 46 and 47 with West street.

The following temporary structures were built, to connect the new piers with the street : A bridge, 40x170 feet, to Pier

No. 45; a bridge, 40 feet wide, from the north side of the ferry platform; a bridge from the south side of the ferry platform. These temporary structures were all subsequently torn up, in addition to tearing up the L on the north and south sides of old Pier No. 51, the old ferry platform at the foot of Christopher street, and the pier at the foot of Barrow street.

Three box sewers were built—from the foot of West Tenth street to the wall; from the foot of Christopher street to the wall; and one from Barrow street 150 feet south along the old bulkhead.

Deliveries of filling began on the 2d of July, 1874, and 80,093 cartloads were received. Between January 11 and February 22, 1875, 104 scowloads of garbage and ashes were received from the Police Department, containing 26,780 cubic yards. The filling now reaches from old Pier No. 52 to about 70 feet south of new Pier No. 43. The money received for dump tickets at this section amounted to $1,080.50.

When the wall was being constructed in front of the ferry platform, in the fall of 1874, it frequently happened that a low tide would not occur during the daylight. In order to take advantage of each tide, and sometimes to finish a course of masonry, with backing up of concrete to get ready for the next day's work, the wall was illuminated by two calcium lights placed 40 or 50 feet apart, within a few feet of the work. On the first occasion that this plan was tried, the result was so satisfactory that the day was afterwards often lengthened until past midnight, and sometimes the workmen were enabled to commence at three or four o'clock in the morning, and this at a cost of about three dollars per hour, a trifling expense compared with the cost of the work accomplished by this mode of illumination.

The wall having been finished up to the coping, between new Piers Nos. 44 and 45, there remained, in front of and about 30 feet from it, the old block forming the north L of old Pier No. 51. The top of this block had been removed and put inside the wall by hand barrows, and Dredge No. 3

was brought in to complete the work, when one of the Commissioners (* * * *), thinking that the operation of placing the stone dredged from the block on the deck of a scow, to be afterwards thrown off by hand, too slow, ordered the Superintendent of Floating Property to bring the dredge alongside the wall, so as to throw the material over and let it fall on the inside. In obedience to orders, this was done, and thus, at each stroke of the dipper, a mass of mud and stone weighing from 3 to 4 tons was taken from the front of the wall, carried over and let fall on the inside, through a distance of 12 to 15 feet. This immense battering-ram had made about fifty blows, when the wall yielded and was broken, about the middle of the stretch between new Piers Nos. 44 and 45. The strength of the wall was shown by the fact that it was not curved, but preserved a straight line from the point of rupture to each end. At the break, it was moved out of line 1.9 inches. When the damage was done, the beam of mass concrete 240 feet long being broken, the foundation piles had lost much of their power of resisting lateral pressure by being inclined, and complete restoration became impossible. To prevent any further displacement, several hundred cubic yards of rip-rap were thrown in front of the wall, forming an embankment, within 8 feet of low water, 20 feet wide at the top, the inner edge of the embankment being 10 feet outside of the bulkhead line.

The power of resistance in the wall itself being gone, and the rip-rap not acting immediately, a further movement took place; until the deflection reached 3 inches, when I ordered the building of a crib, inside, to be attached to the wall with rods and chains and to be filled with stones and sunk. As rip-rap had been put down inside the wall over a width of 25 feet and to a depth of 6 or 8 feet, in accordance with the original plan, and as, through this rip-rap, retaining piles had been driven, 4 feet between centres, it was expected that this crib would settle away towards the street, an expectation fully borne out by the subsequent experiment.

Seven holes were drilled, at low water, over a length of 44

feet 5 inches, in the concrete backing of the wall. In each hole, two staples of 2-inch round iron, 2 feet long, with arms 6 inches long, at right angles, were inserted and cemented. To these staples were secured the eyes of 2-inch rods, which ran back to 1¾-inch and 1¼-inch chains, which in turn were secured to the timbers of the crib when the weighting of the latter commenced. The crib, 28x40 feet, was placed 58 feet away from the wall, where the original soft mud of the slip remained. When the crib was partly filled, the strain was so great as to open some of the hooks in the 2-inch rods. Some condemned 1⅛-inch steel wire rope being at hand, the broken rods were replaced by four parts of this rope, used in the manner of a Spanish windlass, and, when the attachments were again complete, the weighting of the crib went on until 297 cubic yards of stone had been placed in it. This strain on the back of the wall operated to such an extent that the deflection was reduced to 2¼ inches. At this time the filling had reached the water. To relieve the wall still further from the pressure of the filling yet to be put in, a quantity of brushwood, reaching from the wall through the retaining piles, over a space 30 by 75 feet, was spread to a depth of several feet, with a highly satisfactory result.

It has been my endeavor to introduce into the construction of all piers built by the Department, better design, materials and workmanship, than have hitherto prevailed in such structures in our harbor, although this idea was not carried out to such an extent as I desired. At the Christopher street section it was done by building a portion of each pier on columns, 20 by 20 inches square, made up of four pieces of 10 by 10 inch-timber, securely bolted and tree-nailed together; by close planking the bays on the outer ends; by the use of 1½-inch and 2-inch diagonal brace-rods; and by armature plates of ¼-inch iron, from low water to the side cap fitted to the columns, to protect them from the cutting action of ice. These piers have been also greatly strengthened and much improved in appearance by the use of 8 by 12-inch oak fenders.

An attempt at the preservation of the timber was made by painting it with "dead oil," and I believe a wise economy would be shown by creosoting in future all the timber in piers, above the water line, a process which would certainly increase their life twenty or thirty years.

Canal Street Section.

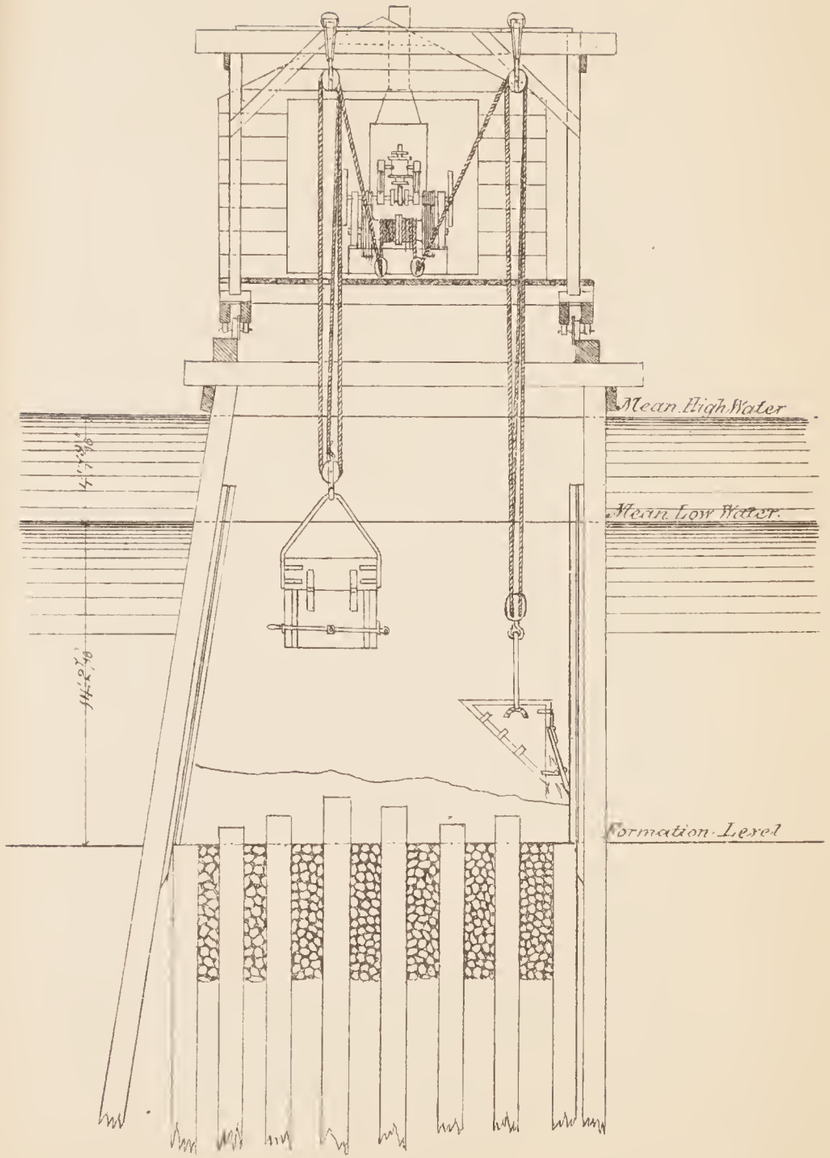
This section was commenced on the 4th of May, 1874, by driving piles for new Pier 34, the present Pacific Mail Steamship pier. It springs from the bulkhead wall, almost in a direct westerly line from the small pier formerly known as 42½, a portion of which is now utilized as a shore connection for the occupants of new Pier 34, and what remains of old Pier 42.

The dimensions of this pier are 583 feet in length by 90 feet in breadth, giving an available area of 52,470 square feet, or nearly an acre and a quarter of space.

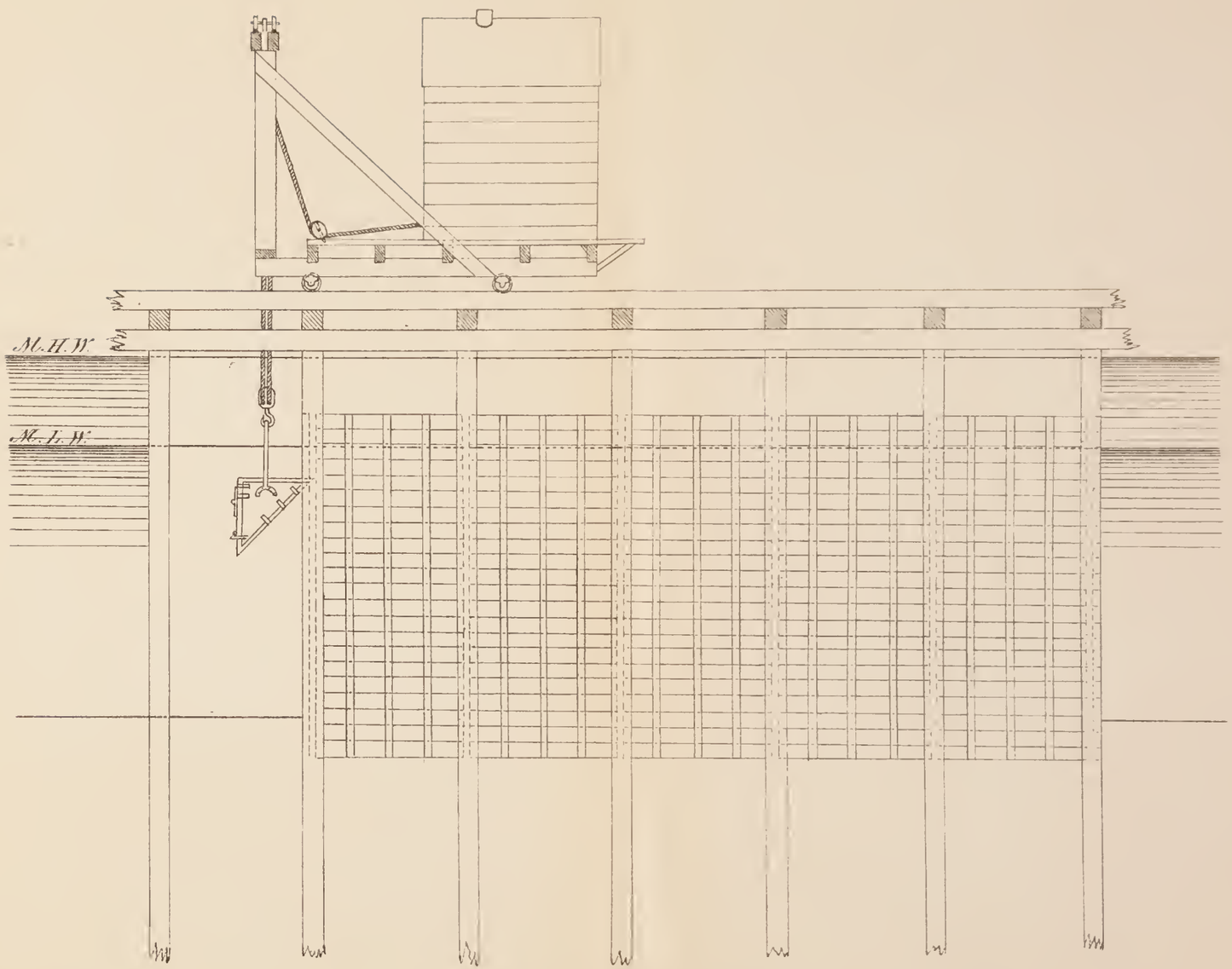
Work was prosecuted with vigor, and by the 1st of September, 1874, the Pacific Mail Steamship Company were in occupation, and paying a large rental to the Department.

* * * * * * * *

To accommodate commerce two connections were made to old Pier 42, viz., for "Pacific Mail Company," and for the "Fort Lee Ferry Company," the latter being cut off from all access to West street by means of a portion of old Pier 42½ having been cut through to permit the building of the stone bulkhead wall. The north half of old Pier 42 was for a distance of 306 feet torn away, and the stone blocking removed and made of use by being transported to the Christopher street section, and deposited behind the bulkhead wall at that point. By this change in old Pier 42 the slip to the south of new Pier 34 is materially widened, giving accommodation to the several occupants of the slips

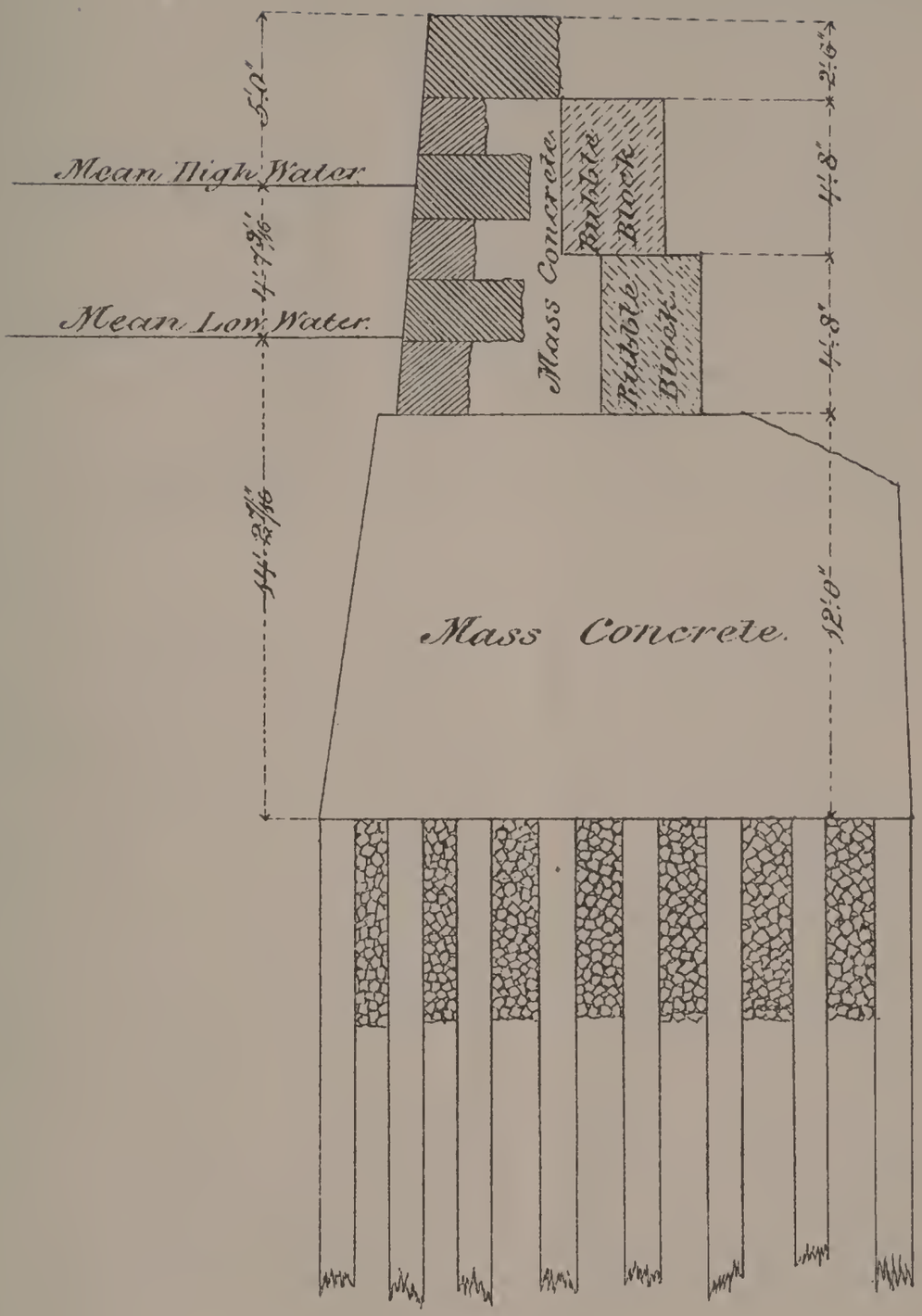


Section of Caisson,
Canal St. N.R.



Elevation of Caisson.
Canal St, N.R.

NOTE.—In preparing these sketches for the Engraver the Draughtsman has omitted to show rip-rap on either side of the wall, as well as stay piles in the rear, all of which have been placed in this method of construction.



Section of Bulkhead Wall

Canal Street, N.R.

American Photo-Lithographic Co. N.Y. (Osborne's Process.)

to the rear of the bulkhead wall, who were of necessity cut off from the street during the progress of the construction of the wall.

* * * * * * * *

The bulkhead wall on this section, 110 feet of which has been finished, foundation up to stone facing for a distance of 80 feet built, and pile work for 60 feet more ready for concreting, is a subject on which I will have to dwell at some length, as the method of constructing it differs materially from that used at the Battery and Christopher street sections. At the latter works the system was—to drive piles. cut them off at a fixed distance from mean low water, and upon them to place prepared beton blocks by means of 100-ton derrick and divers.

On this section, as well as the King street section, the piles are punched down, and loose concrete laid *en masse* in a false work of timber, which is subsequently removed. I will more particularly describe the operations hereafter.

In Great Britain, and in the continental countries of Europe, where the dicta of science are as unhesitatingly received as the truths of Scripture, it would be considered ludicrous for an engineer to give his reasons *in extenso* for the adoption of any particular system of construction; but in this liberal country, where the people are sovereign, and every newspaper reader is transformed into a remorseless critic, it is unsafe to originate any plan without giving unanswerable reasons therefor, particularly when the plan must necessarily extend over a period of many years, and involve in its completion an outlay of from $25,000,000 to $50,000,000.

This must be my excuse for the collation of the following excerpts, which are familiar to every well read engineer. That eminent authority, Mr. Thomas Stevenson, in his work on the "Design and Construction of Harbors," at page 201, says: "Sir John Hawkshaw has passed concrete through 50 feet of water with perfect success. As far as his experience went, the concrete set quite as well under these circumstances, as when it was deposited in the open air. He has

done this both in salt and fresh water. In passing concrete through water, he used a box containing almost 2 cubic yards ; when it reached bottom, a bolt was withdrawn, and the concrete dropped out."

The same authority, on page 202 of the same work, also says : " Mr. W. Parkes put in the foundation of the iron light-house in the Red Sea by means of a caisson, into which the fluid concrete in bags was deposited." He thus describes the method of construction : " During this time some progress was made at the light-house works. The caisson of iron-plates to inclose the concrete base had been deposited upon the reef, where it was exposed to a wash sufficient to remove some of its clayey particles, without carrying it out of reach. As soon as a sufficient quantity of gravel was accumulated, the process of depositing the concrete was commenced. As circumstances did not admit of the usual plan of depositing the concrete in the water in large masses from boxes, the following plan was substituted : Sheets of tarred canvas were prepared of such sizes as would fill up the spaces between the piles, and allow 2 feet round each side, to be turned up, so as to form large shallow bags. The edges of the tarpaulin were then lashed to the wooden rods, which were slung to the piles, so as to allow the tarpaulin bag to float slackly on the surface of the water. Two or three hours below low water the work was commenced. The concrete was mixed in the lighters moored alongside the caisson—6 measures of gravel being used with one measure of cement, and a suitable quantity of water. The materials were thrown into the centre of the canvas bag, which gradually sunk to the bottom (generally from 1 to 2 feet under water), and the bag was spread out evenly over the whole area as it became filled. This was continued until the tide rose nearly to the level of the top of the deposited concrete, when the sides of the tarpaulin were drawn close over the soft mass, and lashed tight. In this way blocks of from 6 to 14 tons were deposited without the material having been subjected, in small quantities, to the action of the water. The blocks were generally hard enough on the fol-

lowing day to allow of the exposed parts of the tarpaulin being cut away; and so complete was the set, that casts of the cords and the edges of the tarpaulin were often sharply impressed upon the face of the concrete."

At the Canal street section, the joints of the caisson were so close, as to admit of scarcely any wash, and being in a slip with block and bridge piers on either side, the current was scarcely perceptible, consequently when the concrete was deposited, little more "laitance" or milkiness was visible than would have been occasioned if fresh made beton blocks prepared on land had been immersed in water. That eminent marine engineer, Sir Charles Hartley, in his valuable report on the "Delta of the Danube," at page 39, says: * * * "and the absence of divers to execute the work, induced the author, at first, to adopt the plan of building the wall on a roughly levelled foundation, by carefully lowering down masses of unset concrete within movable timber-dams, fitted in lengths of from 15 to 30 feet, to the frame-work of the piers. This plan was not adopted on a large scale, until it had been found, by repeated experiments, that the concrete, when made with a sufficient quantity of Portland cement, set perfectly hard on a rocky foundation in a seaway, although lowered through the water in a semi-liquid state."

In passing the cement through the water at Canal street, two separate one-yard tubs were used, and the concrete mixed was comparatively dry and far from a semi-liquid state.

At page 41 Sir Charles further says: "The spaces between the beton blocks used were filled up with newly made concrete, which, searching its way under the adjacent blocks, and filling in the grooves, moulded in their sides expressly to this end, caused the whole mass to become ultimately as solid as if it consisted of but a single stone."

As to the strength of the Portland cement used, Sir John Coode, in his remarks from Hartley's description of the "Delta of the Danube," at page 74, says:

"The cement was tested by Grant's machine to resist a tensile strain of 350 pounds per square inch, after being im-

mersed in water 7 days. He had made large quantities of cement in mass under water and at a considerable depth, with the proportions of 1 of cement to 5 of gravel; he had executed a large amount of such work for some years past, and had built a substantial sea wall to the height of 40 feet upon it."

The proportions used at Canal and King streets are almost identical—1 of cement, 2 of sand, and 5 of broken stone. At page 76, same work, Mr. Coode says: "He had lately put down some foundations for a heavy sea work on a rough, rocky surface, where, if he had not deposited the *concrete in mass* upon the rock, the expense of preparing the bottom to receive the blocks would have been somewhere about twice or three times as great, and the time occupied would have been three or four times as long as was required to execute the works by means of concrete deposited 'in situ' upon the bottom in 16 feet of water at the lowest spring tides."

I further give some excerpts taken from the reports of the Institute of Civil Engineers, London, Vol. 1862-3, a paper by Daniel Miller, C. E., entitled "Structures in the Sea without Coffer Dams:"

"The system of building under water by means of diving-bells and diving-dresses has been practised to a considerable extent; and the improved apparatus, now used, gives great facilities for this kind of work; but it is only applicable under particular circumstances, and it is also *costly*, besides being liable to cause delay in the progress of the work."

"There are three modes in which concrete may be applied for constructive purposes—building it in mass and allowing it to set before water has access to the work, as has been adopted in the construction of the walls of the Victoria Docks by Mr. Bidder, and in those of the London Docks by the late Mr. Rendel—preparing it first in blocks and allowing it to harden before being used, as employed by the late Mr. Walker, at the Dover Breakwater, and by Mr. Hawkshaw for the new sea forts for protecting the arsenals of Plymouth and Portsmouth—and depositing it in a liquid state, and

allowing it to set under water, as practised upon a gigantic scale by M. Noel in the construction of the large Government Graving Docks, at Toulon. In the latter case, hydraulic concrete has been deposited in a liquid state in the sea water at a depth of about 40 feet, forming a vast rectangular trough of beton about 100 feet wide, of the length of each dock respectively, and with walls and bottom about 16 feet thick."

Speaking of the various kinds of hydraulic limes, Mr. Miller says: "It may be useful to mention, for comparison, the proportions of some of the concretes made from these various limes. The *Arden lime* concrete employed by Messrs. Bell & Miller for the foundations of the large Graving Docks at Glasgow was composed of 1 part of ground Arden lime, 1 part of iron mine dust, and 4½ parts of gravel and quarry chips. The *lias concrete* used at the recent extension of the London Docks by Mr. Rendel consisted of—1 part of blue lias lime to 6 parts of gravel and sand. The proportions adopted for the blocks of the Mole at Marseilles were 2 parts of broken stone to 1 of mortar, the latter being composed of 3 parts Tiel lime to 5 of sand." * * * * * "The Portland cement used at the new Westminster Bridge is harder and more compact than the greater number of building stones, even where put down in the bed of the Thames, and where it is exposed to the running stream." * * * "The author had lately an opportunity of examining at Genoa the extension of one of the Moles of the *harbor*, the inner side of which has a vertical wall."

"The latter was in process of being constructed *under water* entirely of pozzuolana concrete, simply thrown into the sea from baskets, carried on men's heads, a boarding confining it to the shape of the wall. In a short period it set quite hard, so as to enable the upper part of the wall, which is of stone, to be built on it." * * * * * "Though the depth of the quay wall was not great, this shows the confidence which the Italian engineers have in concrete applied under water in a soft state. The piers of the new basin constructed by the Austrian Government at Pola, in Istria, are also

formed in a similar manner, of concrete, confined between rows of timber piling. But perhaps the most striking application on a large scale of pozzuolana concrete, is in the great Mole which protects the port of Algiers. To form the Mole, blocks of beton of immense size, so as to be immovable by the force of the sea, were employed, some of these formed '*in situ*,' by pouring the concrete into large timber cases without bottoms, sunk in the sea in the line of the Mole."

"Hydraulic concrete, to be effective, requires great care and attention in its manipulation and in the regulation of the proper proportions of its materials."

"*Any failures must have arisen* from inattention to these or similar points, as there is ample experience to show, that when properly made, every confidence may be placed in the strength and durability."

In the construction of the Albert Harbor, Greenock, the following occurs, same authority: "The mode in which the work was designed was to form the walls under low water, of a combination of cast-iron guide piles in front, with a continuous stone facing, slid down over and inclosing these, and of concrete backing deposited in a soft state, all of which could be easily accomplished from above the water line." * * * * This plan was felt to be so novel, particularly as regards the concrete, that, though the Trustees as a body had the greatest confidence in the engineers (Messrs. Bell & Smith), they considered it to be their duty, before proceeding with the work, to fortify themselves by having the opinion of another engineer; accordingly Mr. Thomas Page, M. Inst. C. E., was consulted, who fully satisfied them as to the efficiency of hydraulic concrete applied in the manner proposed, and otherwise confirmed the soundness of the principles upon which the works were designed.

Again, same authority: "Immediately after being mixed, and when brought to a proper consistency with water, it is conveyed to where it is to be used, is let down under water in the discharge boxes, and in a short time sets very hard. * * * * This mode of constructing walls in deep water, without coffer dams, has proved very successful, and a

sea pier of great solidity and durability has been formed at a comparatively moderate cost." * * *

"Temporary sheet piling or boarding, instead of loose stone, may be employed to keep the concrete in its place until it has set."

General H. G. Wright, of the United States Engineer Corps, an officer of great experience, in a letter addressed to Major-General Hamilton, late Superintendent in Charge of Yards, on the subject of Rosendale cement, among other things, says: "Of this cement I used some 50,000 bbls. in the fort at the Tortugas, a large part of which was for foundations and walls under water; the particular blocks to which I referred were laid to test *the workings of the tremie.* * * * * They were laid in 1848, I think; and when I left in 1856, they were in as good condition as when laid, the surfaces being apparently as perfect. The concrete was made with sea water, no fresh water having been used."

In a subsequent statement, more particularly on the working of the *tremie system*, made lately, that eminent officer said, "The success attending (the above) induced him to construct the foundation of several of the forts in Southern waters in a similar manner, and with like success."

Forts Jefferson and Carroll he cited as prominent examples. "* * * * Should not hesitate to construct foundations under water, by depositing liquid concrete *in mass*, if care was taken in its manipulation."

Besides the valuable experience of General Wright, as above detailed, to my own knowledge mass concrete has been used in this country in the construction of foundations below water for a period of twenty-five years at least.

While Engineer of the Brooklyn Navy Yard I constructed a wall *en masse*, which is a standing witness to-day of the success of the system. My predecessor in office there used somewhat similar means. Mr. McElroy's wall at the Wall-about would have proved a success if attention had been given to the placing of more piles in the foundation, and had the Rosendale cement used, retained its previously high character, and not deteriorated in its tensile strength.

I will now briefly describe the method of placing this mass concrete *in situ* on the works in question.

The wall, up to within 2′ $2\frac{7}{16}$″ (two feet two and seven-sixteenth inches) of mean low water, is made of a huge monolith of concrete *en masse* manufactured on the spot and deposited *in situ*.

The site for the wall was first thoroughly dredged to a mean depth of 20 feet below mean low water; piles were then driven, 8 in a cross section of 17 feet 6 inches, and of an average distance of 2 feet 6 inches from centres, except the two front rows, which are centred two feet; longitudinally the outer and inner rows were driven as close as could be done without interference; they were punched to about a mean distance of 13 feet below mean low water, by means of a heavy oak follower 26 feet in length and 12 inches in section, armed at the bottom with an iron pintle and banded with iron to strengthen against fracture; this punching obviated the cutting off of any other than the westerly row, and those only for a distance of 180 feet; this uneven punching afforded a good grasp to the concrete around their heads. Broken stone, measuring about 4 cubic inches, was then filled in between the piles and allowed to take a bearing. The false work for receiving the concrete was then erected. Yellow pine square piles, 12 inches by 12 inches in section, and of an average length of 40 feet, were driven in front of the westerly row of punched piles at a batter of 1¾ inches to the foot, and on the back at a batter of ½ inch to the foot, centred longitudinally 8 feet; to the inside of these square piles, previous to their being driven, battens of 4 inches by 2½ inches spruce were nailed on firmly, and on these further pieces of spruce, 12 inches by 2 inches, were fastened, forming grooves for receiving constructed wooden shutters or gates which were slid into place after the pile alignment was perfected. These piles were then capped crosswise by square 12-inch timber, braced laterally by walling pieces 12′x6″, and on these cross caps stringers were laid, on which were placed rails of flat iron to receive the wheels of a movable platform car, bearing on it a 10 horse-power engine for the lowering

of the concrete into the caisson. This platform car had erected on it a gallows frame holding traverse wheels with pendant bales of iron, from which were suspended double block purchases for the lowering and hoisting of two separate 1-yard buckets, each working from a separate drum independent of the other, so that one bucket could be lowered while the other was filled.

The concrete was mixed on a platform in the rear, constructed on the stay piles driven in the rear of the wall, wheeled to the car, dumped into the buckets or tubs, and then lowered into the caisson. The door of the bucket being opened from above by a trap rope, did away with the necessity of employing divers, and the only occasion when divers were used at all was when Mr. McDonald, foreman of masons, himself a practical diver, levelled off the top layer of concrete to receive the granite facing. The buckets could be shifted from above in such a manner as to command any portion of the bottom.

The proportions of the concrete varied occasionally, but the usual proportions were, as before stated, 1, 2, and 5, or 1 part cement (Portland), 2 of sharp sand, and 5 of small broken stone.

Concreting was commenced on the 24th of December last and continued until the 6th of January, 1875, a layer of 2 feet being spread over the bottom, soaking into the broken stones at the bottom, and binding the pile heads firmly together. The quantity of ice by this time proving very troublesome, concreting was suspended until the middle of March (though further piling for the wall was continued throughout the winter, with scarcely any intermission), and vigorously prosecuted until the end of April, when the whole mass necessary was placed. In the hearting of the caisson, one-fifth of granite spawls, from the Departmental Stone Yard, were placed and thoroughly grouted, preserving the stability of the wall and lessening the expense.

In placing the concrete in water, chilled sometimes to 3° colder than the freezing point of fresh water, some means had to be adopted to counteract its chilliness. That eminent

and versatile engineer, Mr. Chanute, in his report on the Kansas City Bridge, says :

"Both masonry and beton were laid in extremely cold weather, the use of hot sand and water being found to make this practicable. The sand was heated in large sheet iron braziers, and the water warmed in cast-iron kettles, one of each being found sufficient to supply the force working on a pier. The heat which was thus artificially given to the mortar hastened its setting, causing this to take place before the mass had cooled enough to make freezing possible."

Mr. T. C. Clarke, in his able and exhaustive report on the Quincy Bridge, says :

"During this time the glass fell as low as 16° Fahr. A shanty was built on a flat, and in this a kettle was placed on a stove, and the cement mixed with hot water. During the coldest days each stone was, before being set, held over a brazier of charcoal to draw out the frost. The mortar was examined carefully in the spring, and found to be as hard and perfect as any on the work. Much of the masonry of this bridge was constructed during winter, although none in as cold weather as this pier, *and there is apparently no difference in the quality of the mortar* whether built in *winter or summer*."

As the quantity of cement used by these gentlemen was very small in comparison with that which would have to be used in the bulkhead wall in question, some means had to be taken of a more extensive nature. For heating the water, the following simple apparatus was used. A cask capable of containing 60 gallons of water, holding a coil pipe, was placed on the movable car, and through this coil the steam from the boiler of the engine was passed at will ; this heating was done very rapidly and efficiently, it only taking from 4 to 8 minutes to heat the whole 60 gallons from 32° to 100° Fahr., the water thus heated being carried to the mixing platform by india-rubber tubing. To heat the sand and broken stone, heaters made of iron, similar to those used in street paving, were constructed by Mr. Joseph Edwards, 414 Water street, New York, each capable of heating a cubic yard of material,

the fuel used being old barrel staves, etc. They did their work thoroughly, and by this means work was carried on, on one occasion when the temperature of the air was 11° Fahr. and that of the water 32°, the concrete becoming as hard as if made during the hottest summer months, thus practically substantiating the opinions of Messrs. Chanute and Clarke.

In laying the backing to the granite facing I have introduced a change from that at Christopher street section, which has materially lessened the expense, while preserving the stability of the wall. Blocks of about three cubic yards capacity were made at the Seventeenth street yard out of old granite spawls and Portland cement; when sufficiently compact they were transported to Canal street, and placed in position with great rapidity, over 70 lineal feet being laid during one tide. The success attending the use of these rubble blocks has been such that I have recommended to the Board in my report on the "Development of the Harlem River and Spuyten Duyvil Creek for Commercial Purposes," that the bulkhead wall when constructed should be composed of beton placed *en masse* with a rubble masonry facing surmounted by a granite cope.

On the removal of the shutters and square piles—the false work of the caisson—which had been down nearly three months, Mr. McDonald carefully examined the sides of the monolith and reported that he found it as smooth and compact in appearance as any blocks he had ever seen which were manufactured on land—and no sign of honey-comb. This assertion was verified by my assistants, who passed a boat hook all along the sides both front and rear, and found it as smooth as the Gansevoort street manufactured blocks; the edges of the "berme," too, 6 inches in width where the stone facing springs from the monolith of concrete, was as distinctly defined as that of a well cut piece of granite. A great saving has been effected by this system of construction, over that of the block system, including coping not as yet required on this section (the wall constructed being in the wake of the pier); the saving amounts to $67.77 per foot

run, or over $350,000 per mile, the cost per foot run being $311.67.

By having a long stretch of work, a judicious use of labor, and using made rubble blocks surmounted by granite cope, instead of cut facing, I am of the opinion that the cost can be reduced at least 20 per cent.

It is worthy of notice, before leaving this section, that in the pile foundation, now waiting stone-packing, driven to the north of the already completed wall, 207 old piles, drawn up from the north half of old Pier 42, and which had been down for a period of over 25 years, were driven in the foundation, the only fact noticeable being, that a few of the heads required recutting; otherwise they were as good as the day they first were driven.

King Street Section.

The dredging for the river wall between old piers numbers 45 and 46 was begun November 16, 1874, and amounted to 3,600 cubic yards. The foundation is to be 17½ by 147 feet, and 678 piles were driven. The caisson, 147 feet long, is constructed in the same manner with that at Canal street, and 626 cubic yards of 4-inch stone have been thrown in, and 1,225 cubic yards of rip-rap stone have been placed in front and rear of the caisson.

Gansevoort Street Yard.

The following alterations were made at Gansevoort street yard, during the year:

The manufacture of beton blocks for the river wall being no longer carried on at this yard, the platforms upon which about 9,300 cubic yards had been made during the previous two years, were removed.

The preparations for surrounding yard number 3, involved the removal of a large amount of varied stores and materials.

The grade of the yards and bulkhead was raised an average of three feet, to conform to the new level established, with ashes and like material delivered by the Street Cleaning Department.

A new blacksmith shop was built in the middle yard ; the grade of the store-house floor was changed, and one-half of the large store-house was partitioned off into small store-rooms for the floating property, and repairs and supplies, and an office, leaving the other half, which is 164 feet long by 24 feet wide, for the storage of cement, with a capacity of 3,400 barrels. The fences and gates of all the yards were also raised.

Yards hitherto known as "yards numbers 1 and 3" have been turned over to the Commissioners of the Sinking Fund, yard number 2, with one pier, being retained for the uses of this Department. The dimensions of yard number 2 are 163 feet in length by 52 feet in width, in which has been built the new blacksmith shop, the remaining space being occupied by a shed for forge coal, a bin for hard coal, containing about 39 tons, and for the storage of wheelbarrows, lumber, beton moulds, and miscellaneous material.

For a detailed statement of purchases, receipts, and deliveries of every description, and of articles manufactured, and stock on hand, reference is requested to the returns from Gansevoort street yard in the "Appendix" accompanying this report.

East Seventeenth Street Yard.

During the year about 1,300 feet of narrow-gauge railway has been constructed at this yard, at an average cost of one dollar per running foot. This, with four cars, made at the yard—two for cement and two for granite—greatly reduces the

cost of loading and unloading stone and cement. The railroad also renders every part of the yard available for storing stone, while formerly only the bulkhead could be used for that purpose.

The store-house, besides the portion used for storing iron bolts, and small articles, and the carpenter's shop, can conveniently receive about 5,000 barrels of cement.

The blacksmith's shop contains four forges, three of which would be sufficient to sharpen tools for a force of thirty stone-cutters, and the remaining forge could be used for any general blacksmith work required by the Department along the East river front.

The cost of stone-cutting for the year, at $1.42 per cubic foot, is less than the same work could be done for by contract. This result has been attained by the system of keeping an account of the work done by each stone-cutter, and requiring all to come up to a certain standard. The yard itself possesses great advantages, either for cutting stone or simply for storing it until required for use at the several sections. Besides the space occupied by buildings, it has an area of $2\frac{1}{5}$ acres, available for storage purposes, with a bulkhead front of 645 lineal feet.

Between April 10th and May 14th, 1875, there were manufactured at this yard 36 rubble blocks, at a cost of $9.77 per cubic yard. The first 18 of these blocks cost $10.70 per cubic yard, and the last 18 cost but $8.84 per cubic yard; the lesser cost of the latter being due to the fact that the platforms upon which they were built were all finished for the first lot, and, consequently, no carpenter work enters into the estimate.

Floating Property.

The floating property of the Department of Docks is as follows:

Three tug-boats, in good condition, with the exception of the Louis, undergoing repairs.

Four dredges, all in good condition.
Nine pile-drivers, all in good condition, except "No. 6."
Eighteen mud-scows, all in good condition except four.
One patrol-boat.
Eleven deck scows—four of them new.
One boring machine, for taking soundings.

For details of floating property and of dredging, etc., performed during the year, see "Appendix."

General Repairs.

The general repairs to old piers and other structures, performed since February 1, 1875, at which time work of this class was placed under my supervision, were as follows:

The dumping-board at the foot of Forty-sixth street, East river, was repaired on the 10th of February, and again on the 4th of March.

At Blackwell's Island three platforms were built, for the use of the Police Department scows, and of the following dimensions: 51x31½ feet; 43x32 feet; and 41x26 feet; constructed between February 27th and March 10th.

At Randall's Island an extension on a pier was built, 23 feet long by 74 feet wide, from March 9th to 19th.

Repairs were made on Piers Nos. 40 and 41, East river, February 26th to March 26th; Pier No. 6, East river, March 20th to 23d; Pier No. 7, East river, March 25th to April 5th. These repairs consisted mainly in work at the outer ends of the piers, which had been damaged by the ice, as in putting on fenders, corner bands, clusters and spring piles.

The bulkhead between Gansevoort street and Little Twelfth street was raised two feet, for a length of 733 feet, to conform to the grade of Thirteenth avenue, between March 20th and April 6th.

The bulkhead at the foot of East Seventeenth street was repaired and strengthened, for a length of 450 feet, by driving down 49 piles, April 2d to 10th.

Pier No. 37, East river, was repaired, with spring piles, chocks, and fenders, April 6th to 14th.

The pier at the foot of Twenty-eighth street, East river, was repaired, with new fenders and backing logs, April 14th to 19th.

The pier at the foot of Twenty-fourth street, North river, was extended, 50 by 50 feet, April 14th to May 5th.

A platform, 100 feet long, extending out 20 feet, was built against the bulkhead at the foot of One Hundred and Thirtieth street, North river, April 16th to 24th.

Pier 46, East river, was repaired, April 21st to 27th; the pier at the foot of Forty-sixth street, North river, April 26th to 27th; the pier at the foot of One Hundred and Fifty-fifth street, North river, April 26th; the pier at the foot of Twenty-sixth street, North river, April 27th to 30th; the bulkhead between piers Nos. 45 and 46, East river, April 28th to May 1st, and the pier at the foot of Forty-seventh street, North river, April 27th to May 1st.

A cluster of piles was driven and secured to the end of Pier No. 38, East river, to keep vessels off the old block.

On the 30th of April the following works were in progress: Repairs at the foot of Twenty-fifth street, North river; at Fifty-first street, North river; and the tearing up of the pier at the foot of Ninety-sixth street, North river.

The damage to piers from floating ice has been unusually severe during the past winter. Ninety piles were cut from under the pier at the foot of One Hundred and Twenty-ninth street, North river, leaving the deck unsupported for about 100 feet. All but about 50 feet of the pier at the foot of Ninety-sixth street, North river, was entirely carried away, and, on the East river, the ends of Piers Nos. 12 and 38 were entirely wrecked.

For the general repairs performed prior to February 1st, 1875, under the supervision of the Superintendent of Repairs and Supplies, and for more minute details of work accomplished, I would refer to the "Appendix" accompanying this report.

Harlem River.

The great difficulty which has thus far prevented the improvement of the Harlem river has been the clashing of authority, delegated by the Legislature to the different commissions.

April 15th, 1871, an act was passed giving the Department of Public Parks full power "to build or construct, by contract or otherwise, any and all improvements in the navigation of Harlem river and Spuyten Duyvil creek, which said Department might plan or locate."

Three days after the passage of the above act another was passed, which amended the "act creating the Department of Docks," and provided that the plans of this Department, when confirmed by the Commissioners of the Sinking Fund, should constitute the sole authority for the solid filling in the waters surrounding the City of New York, and repealing all other provisions of law regulating solid filling and pier and bulkhead lines in said waters.

Thus by the latest act the "Department of Docks" was given the authority, with the confirmation of the Sinking Fund Commissioners, to lawfully supersede any lines established by the Park Commissioners or by any other commission.

The authority to determine upon a plan or plans for the improvement of the whole or any part of the water front of the city, was so clearly the prerogative of the Department of Docks, that the Park Commissioners, in a report to the Senate April 1st, 1872, made use of the following language: "A question having arisen as to the jurisdiction of the Board over the Harlem river, the work, so far as related to special hydrographic objects was suspended, and only so much as relates to other objects has since been continued.

In March, 1872, the Commissioners of the Department of Docks submitted to the Commissioners of the Sinking Fund new pier and bulkhead lines for that part of the city north of

Sixty-first street, including the Harlem river and Spuyten Duyvil creek. These lines were neither accepted nor rejected by the Sinking Fund Commissioners.

Although as far as the Harlem river was concerned, it made but little difference, as the lines submitted by the Dock Commissioners were almost identical with the then existing lines which had been made by the Park Commissioners in 1868.

In this condition of affairs the new Charter was passed April 30th, 1873, which rescinded the authority previously delegated to the Department of Docks, and in the following language it is claimed by the Department of Parks, confirmed their lines: "There shall be a Department of Docks, the head of which shall be a Board consisting of three persons, * * * who shall possess such power and perform such duties, as are now possessed by the existing Department of Docks, but said Board shall not have the power to change the exterior line of piers and bulkheads as now established by law."

The Charter by taking away the power from the Department of Docks to establish pier and bulkhead lines effectually suspends the improvement of the Harlem river, for no improvement of a permanent character and based upon a knowledge of the tidal laws in this and the Hudson river, can take place, until the existing lines in this locality are changed, or, in other words, until the section of the improved river, instead of being contracted in Spuyten Duyvil creek is made as wide or wider than the Harlem river.

In brief, the whole improvement of the Harlem river and Spuyten Duyvil creek consists in so adjusting the lines of solid filling, as that the best interchange of tides between the East and Hudson rivers may take place; and, inasmuch as the existing lines were planned without any reference to the flow of the tides, to have them legally changed is the first step towards the improvement of these rivers.

In April, 1874, the Legislature passed a joint resolution, calling upon the Department of Docks to make the necessary surveys and soundings from the mouth of the Bronx river to the southerly boundary of Yonkers, in the recently annexed

Twenty-third and Twenty-fourth Wards. Instead of at once entering upon the survey, with the view of giving the city an accurate map of the water front in these wards—a want which is still severely felt by those holding property along the Harlem river—nothing was done in the matter.

The very full reports furnished by me in relation to this survey, and which accompanied the recent report of the Commissioners in answer to the concurrent resolution of inquiry by the last Legislature as to the reason of the work not having been prosecuted, contain the reasons, in detail, why the numerous surveys that have been made in this region from time to time do not meet the present wants.

The assertion contained in these reports that "No complete hydrographic map of the Harlem river, Spuyten Duyvil creek, and the water front of the recently annexed Twenty-third and Twenty-fourth Wards, exists at the present time" is still true, notwithstanding the recent survey made by General Newton. This, while an excellent one of its kind, and useful for certain purposes, entirely fails to furnish the detailed information required to locate the water front of a rapidly-growing city, nor could it be considered as anything more than a preliminary survey, in the event of any extensive river improvement being entered upon.

The survey called for by the resolution above mentioned, is required, whether the Harlem river be improved or not; but should any measure be adopted for the readjustment of its bulkhead lines, the necessity for this survey will be more apparent than ever.

Should the Department of Docks be vested with the power, by the Legislature, to establish permanent lines for the solid filling on the Harlem river, these lines should be, as I have shown in a report made to this Board May 20, 1875, either parallel lines through the Harlem river and Spuyten Duyvil creek, or lines diverging from the Harlem river, so as to increase the section of the improved river at its mouth on the Hudson. Where continuous parallel bulkhead lines are insufficient to accommodate the requirements of commerce, the system of parallel piers being entirely inadmissible in

consequence of the narrowness of the river, I advocate the construction of wet basins within the masonry bulkhead.

The bulkhead wall, when constructed, should be composed of beton, placed *in situ*, with a rubble masonry facing, surmounted by a granite cope.

In conclusion, I desire to express, in the most emphatic manner, the wisdom of adhering to the natural channel of the river, as proposed by the Harbor Commissioners in 1857, the Department of Parks in 1868, and the Department of Docks in 1870.

Artificial channels, for the purpose of making short cuts between portions of the same river, or between a river and bay, are of doubtful utility at the best, and when such a canal would, as in the present instance, intercept established lines of communication between the city and the recently annexed territory, and destroy the value of a vast amount of property which has already been partially improved with a prospective view to its occupation for commercial purposes, its construction should not be thought of.

North River.

In 1834 Commissioners were appointed by the States of New York and New Jersey, to define the boundary line between these two States in the Hudson river and New York bay, and their report was ratified and confirmed by their respective Legislatures and by Congress.

If some joint action of this kind had been taken by the two States, in 1855, when New York appointed a Commission "for the preservation of the harbor," the vexed question of encroachment in the coterminous waters of New York and New Jersey might have been settled forever.

That the New York Harbor Commissioners were fully sensible of the fact that their work would only be half done, unless in some way it could receive the sanction and co-operation of New Jersey, we can see from their report in

which they say : " It was obvious that the preservation of the harbor, and a just regard to the interests of the States, required that proper limits should be defined on either shore, and that these limits ought to be simultaneously determined. If, in the absence of restrictions, piers were unduly projected into the river from one shore, they might have an injurious influence on the other ; or, if from both, there was reason to apprehend that the navigation of the river would be affected."

Entertaining these views, the New York Harbor Commissioners addressed a communication to Governor R. M. Price, of New Jersey, asking him whether, if they laid pier and bulkhead lines for both States, they would be accepted by the State of New Jersey.

To this the Governor responded that any lines laid down for the New Jersey shore, while they would be received with great confidence for impartiality, could not be legally fixed or accepted without being confirmed by the respective Legislatures of New York and New Jersey, and by the Congress of the United States.

Here the matter rested. The New York Harbor Commissioners laid down pier and bulkhead lines for both shores in the Hudson river and New York bay, but they were never accepted by New Jersey.

In 1865 a report was made by Commissioners appointed by the Legislature of New Jersey, which contained a survey of the land lying under the waters of the Hudson river and New York bay, with proposed pier and bulkhead lines for this locality.

The lines laid down by this Commission are the governing lines, I believe, at the present date. Whether they were determined with any reference to maintaining the capacity of the Hudson river as a tidal reservoir, and thereby keeping the channel at Sandy Hook the same, or whether the more narrow policy of looking after local interests merely prevailed, I am unable to state; but I should think the subject important enough to warrant the appointment of a joint commission by both States, and after their report shall have been

made, to lay the matter before Congress for final confirmation, just as was done in the boundary question in 1834.

It seems not a little curious that such an important question, in which both States are equally interested, should have slumbered so long; and not only New York and New Jersey, but the Federal Government itself, is interested in preserving the best harbor of the country, which yields by far the largest revenue.

The most thorough and intelligent representation of the whole subject was made by the Harbor Commissioners, in 1856, to both State Governments; and it is to be much regretted that in neither State have their lines been adhered to in the controlling sections of the Hudson river.

The gradual but constant advancement of Sandy Hook toward the channels from the ocean, will, at some future date, seriously affect the commercial supremacy of the port. Within a century it has increased a mile and a quarter, and in the twelve years from 1844 to 1856, it advanced a quarter of a mile.

Various causes have been assigned for this alarming progression; but while no one of them seems sufficient to produce the result, it probably arises from several.

Among the principal of these, are the indiscriminate dumping of ashes and other solid material in all parts of the harbor, and the extension of the pier and bulkhead lines at points where the river should not be contracted, and which has resulted in the partial exclusion of the tidal waters.

East River.

I would respectfully suggest, in connection with the proposed improvements on the East river water front, that this work should not be entered upon by the Department until the modifications and changes in the existing lines, as recommended in my letters to the Board of February 12, and March 16, 1875, shall be authorized by the Legislature.

These changes contemplate, first, a reduction in the width of the river street, from the Battery to Corlear's Hook, and in the length of the piers in the same locality; and, secondly, to omit altogether the precise location of the new piers, establishing merely the pier and bulkhead lines. Determining the location and dimensions of new piers in advance of the demand for them, is productive of serious embarrassment to the Department, and I am firmly convinced that all that is required in reference to these piers, at this time, is the establishment by the city of a pier line or limit of encroachment, beyond which no structure should be permitted.

It should by no means, however, be made obligatory on the Department to carry all their piers out to this line; on the contrary, specific dimensions should be left to the discretion of the Board of Commissioners, and should be decided from time to time, by the demands of commerce in each locality, as well as by the ascertained configuration of the shore and river bed.

The width of the channel in the East river upon which the calculations of General McClellan were based, for the lines proposed in 1870, has been materially reduced since then by the extensive and unrestrained construction of solid bulkheads and projecting works on the Brooklyn side. This shows the necessity of the Legislature fixing the limits on both shores simultaneously, and with reference to the preservation of the harbor.

Fortunately, in this case, both sides of the river are within the jurisdiction of the same State, and we do not have the complication which exists in the settlement of similar questions affecting the Hudson river side of the city, of a treaty with New Jersey, and the necessity of its ratification by the Congress of the United States.

The Contract System.

In my judgment, derived from my experience in the construction of the several works described in this report, the

contract system cannot be economically or successfully applied in carrying out the plans of this department. It will at all times be necessary so to manage operations on any given section of the river-wall and the slips and piers belonging thereto, as to cause the least possible obstruction to commerce, and this will involve as at the Christopher street and Canal street sections, the construction, maintenance, modification, and removal, of a system of temporary connections, and the like, which, from the very nature of the case, could not be foreseen and calculated with sufficient accuracy to admit of proper description in specifications for a contract. On the other hand, should a contract for any such work be made without provision for such inevitable interruptions and outlays, the city would be involved in interminable disputes, as well as made liable to vexatious claims for damages and demurrage.

In view of this necessity of dispensing with the contract system on all new work, I have steadily endeavored so to simplify the method of construction as to admit of the employment of the largest possible proportion of unskilled labor; and it had been my intention to still further extend the application of this idea upon the works yet to be undertaken.

A striking commentary upon the undesirable nature of the contract system, in connection with structures upon whose constant use the commerce of the city is necessarily dependent, is to be found in the history of our general repairs, during the past season. The piers at the foot of Clinton street, East river (No. 38), and at the foot of One Hundred and Twenty-ninth street, North river, were carried away by the ice on the 18th of March, and the proposals for contracts for rebuilding them were opened on the 11th of June. If we suppose these piers, instead of being in localities where the demand for their use was comparatively unimportant, had been in the lower part of the city, say near the foot of Warren street, it will at once appear that the system which would have deprived commerce of their use for so long a time, must be radically defective. In any extended destruction of wharf property, by fire or flood, the contract system would

be found an incomparably greater calamity than either the flood or the fire. Neither is it true that the city cannot find honest and capable servants, who will so manage the duties intrusted to them, as to insure economy as well as all other desirable results.

Conclusion.

In time of war it is customary to commend the gallant acts and daring exploits of individuals in the official reports. Why this custom has not been more generally extended to the pursuits of civil life, has often been a matter of surprise to me. Peace has her victories as well as war, and churlish indeed must be the leader, in a great civil work, who withholds from his subordinates the meed of praise which is their due.

Coming into the Department an entire stranger, I should have been much embarrassed, but for the loyalty of certain gentlemen to the profession to which they and I belong.

Conspicuous among these was Mr. John D. Van Buren, Jr., late Assistant Engineer of this Department, and now a member of the State Commission for the investigation of canal frauds. In the construction of the works at Christopher street, of which he had the immediate supervision, Mr. Van Buren, by his professional attainments, his untiring industry, and his strict integrity of character, won my admiration and respect, and rendered this arduous undertaking a pleasure.

To Mr. C. B. Kid, Assistant Engineer, formerly Mr. Van Buren's coadjutor, and subsequently his successor, I am likewise under obligations, for the unswerving fidelity as well as for the varied knowledge and skill he displayed on several trying occasions.

To Capt. W. W. Maclay, the industrious and skillful Assistant Engineer, who fitted out the East Seventeenth street yard, making it the most complete work-yard in the

country, and carried out a system of supervision by which the labor performed by each stone-cutter could be accurately demonstrated, I owe my hearty thanks.

To Mr. W. N. Radenhurst, Inspector of Engineering, who has so ably supervised the construction of the Canal street section, which may be regarded as a trial work, and who likewise assisted me on many occasions, in elaborate calculations and difficult reports relating to important subjects connected with my duties, I desire to express my most earnest appreciation.

To Edward McDonald, Master Mason, whom I found a mere diver, and advanced to the most important mechanical post connected with the masonry bulkhead, I desire to express my appreciation of his practical knowledge, steady industry, and able management of the force under his control.

Mr. Thomas Murphy, Superintendent in charge of construction at new Pier No. 1, North river, is entitled to a hearty recognition of the manner in which he has performed the duties originally intrusted to him by Gen. McClellan.

To Messrs. Staats, Surveyor; Aitken, Recorder; Rathbone, Chainman; and to the several foremen and timekeepers of the various works, I likewise feel myself to be under many obligations.

To Mr. W. O. Stoddard, the Chief Clerk of my office, who has supervised the labors of my desk, and assisted me by night and by day, in conducting a large correspondence and in the preparation of my reports, I feel that much praise is due. Very respectfully,

Your obedient servant,

(Signed) CHARLES K. GRAHAM,
Engineer-in-Chief.

All the appendices referred to in the body of this Report are omitted, as this edition is merely issued for private distribution.

ADDENDA.

237 Broadway, New York,
July 13, 1875.

On the 2d day of June last I resigned my position as Engineer-in-Chief of the Department of Docks, and on the 9th day of the same month it was accepted. Up to this time, in consequence of the onerous character of my duties, not a syllable of this report had been written, although it should have been in the hands of the Secretary of the Board at least a month earlier; consequently, conceiving it to be a matter of honor to prepare it before taking final leave of the Department, I remained without pay until it was completed, on the 19th day of June.

In the haste of preparation certain matters of consequence may have been omitted, and others of minor importance may have received more attention than was their due. In estimating its merits, I trust these facts will be taken into consideration.

CHARLES K. GRAHAM.

Pier No. 1.

Until the spring of the year 1874, all the beton blocks were manufactured at the Gansevoort street yard, and were transported in scows to the points where they were to be used; consequently the large derrick was employed at least two-thirds of the time merely for lifting purposes, and only one-third of the time in the profitable process of construction.

A sufficient stretch of the masonry wall having been finished adjacent to Pier No. 1 to allow filling in, platforms were erected on the reclaimed land and the manufacture of blocks for the pier commenced there. At the same time it was deemed advisable to reduce the height of the pier blocks, as the cost of manufacturing a block 14 feet in height greatly exceeded that of one 6 or 7 feet high, and, moreover, the large derrick had been so continuously employed that it was unwise to imperil her usefulness by lifting such large masses, as in the event of a serious accident occurring to her, there was no machine, either attached to the Department or the property of private parties, which was capable of taking her place.

As the large derrick was occupied a greater portion of the year 1874 on the Christopher street section, little progress could have been made at Pier No. 1 but for these changes; and towards the close of the year when work was being prosecuted vigorously on all the sections, the reduction in the size of these blocks enabled Delamater's floating derrick to be advantageously employed in placing them.

As stated in my report, I at one time contemplated a change in the foundations of Pier No. 1, and in order that this proposed alteration may be thoroughly understood, the letter to the Board, suggesting it, is annexed.

NEW YORK, March 17, 1874.

EUGENE T. LYNCH, Esq.,

Secretary of the Board of Docks:

SIR—As we are about to resume operations on Pier No. 1, N. R., I consider it my duty to call your attention to certain weak points in the foundations of that structure, and suggest a method by which they may be overcome, with a great saving in cost of construction and a probability that the work can be completed several months earlier by its adoption.

The plan proposed by General McClellan calls for timber-cribs, filled in with concrete, upon which the sub-piers are to rest.

The objection to the use of cribs are—

First. The difficulty of placing them in position, owing to the force of the current.

Second. The impossibility of making an accurate fit of their lower edges to the rocky bottom of the river.

Third. The fact that the concrete has to be lowered through from 25 to 40 feet depth of water and deposited in the crib by divers. In the passage through the water much of the cement is removed, rendering the concrete weaker. In the process of filling, very little force can be exerted by the diver, as he has almost as

much as he can do to take care of himself; consequently the material cannot be properly rammed, and large openings may exist in the foundation which time alone can develop.

In place of the crib foundation, I propose that a foundation of rip-rap should be placed, from the eighth crib, now ready to be laid, up to and including the pier-head, at a depth of 28 feet below mean low water.

The advantages of this foundation are—

First. That it can be commenced immediately and continued without interruption until it is completed.

Second. That it can be weighted, as it progresses, with twice the superincumbent weight it is intended to bear, and brought to a soild bearing.

Third. That the large expense incurred by and the uncertainty attending the use of divers may be, in a great measure, done away with.

Fourth. That no concrete or beton will have to be employed, except that which has been properly manufactured in moulds and exposed to the air until it has been thoroughly hardened.

To counterbalance these advantages, but one objection can be urged—the reduction in the water-way; but, as the reduction proposed, as will be seen by the accompanying statement, will only amount to 6 $\frac{35}{100}$ per cent., and the saving in cost will alone be at least $50,000; I do not think it should be seriously entertained.

Your obedient servant,

(Signed) CHARLES K. GRAHAM,
Engineer-in-Chief.

My last important official act was to address the annexed communication to the Board.

JUNE 8, 1875.

EUGENE T. LYNCH, Esq.,
Secretary of the Board of Docks:

SIR—On the 27th of January last, I had the honor to make the following reply to a communication from the Board of Commissioners governing this Department:

"In response to the resolution of the Board of Commissioners governing this Department, of the 21st inst., with reference to the reduction of the proposed length of new Pier No. 1, North river, I have the honor to say, that, in my judgment, there are no engineering difficulties in the way of the construction of that pier to a full

length of five hundred feet, but I submit, nevertheless, that it would be unwise to do so, for the following reasons:

"The situation of the pier is so exposed, and it is so open to the effects of the southeast winds, that, during a large part of the year, it can only be advantageously occupied on the north side: for this reason and likewise, because of the insufficient depth of water alongside the pier, the depth at mean low water, in some places, not exceeding 21 or 22 feet, and of the rocky nature of the bottom, this pier can never be occupied by steamships of great length and draft.

"Moreover, this excessive length of five hundred feet would render the pier an obstacle to vessels coming in the Bay and intending to round to in slips not very distant from it.

"For reasons given above, this pier will probably be occupied, when completed, by some large railway corporation for the receipt and delivery of heavy freight.

"I now respectfully recommend that the length of Pier No. 1, North river, may be reduced to 425 feet, for the reasons already assigned in the above communication, and for the following, in addition:

"1. Mr. Isaac Newton, the Assistant Engineer, in charge of the construction of Pier No. 1, stated to me shortly after my appointment, that he had already advised Gen. McClellan to reduce the pier to a length of 400 feet, and he has recently stated to Mr. Radenhurst, Inspector of Engineering, that there was a letter from him to Gen. McClellan, on file, to that effect. This latter must be a mistake, however, as it cannot be found in any of the letter-books.

"2. Scientists agree that a diver cannot work effectively in a depth of fifty feet of water, even when it is clear and free from current.

"3. Practical divers tell me that it is impossible for them to work advantageously in a three-knot current; consequently, it is my conscientious belief that if divers are employed in the increased depth of water and accelerated current at the termination of the pier as at present proposed, their operations will consist in little more than holding on to the foundation of the pier in order to prevent themselves being swept away.

"4. It will be observed that from the seventeenth arch to the pierhead, in a distance of seventy-five feet, the rock bottom shelves ten feet, running from 45 feet to 55 feet.

"If the pier is reduced to the length suggested, it can be completed this season without difficulty, and at a saving to the Department of at least $75,000. This estimate allows for the price of the granite furnished for the entire pier, the unused part of which may be utilized on other portions of the work."

I was given to understand, at the time my above quoted communication was received, that the majority of the Board, as then constituted, was in favor of the reduction proposed, and in view of the fact that changes in its membership have since occurred, I deem it my duty at this time to renew my recommendation with reference to a permanent structure of such extent and importance.

The work is now progressing so rapidly that the question involved should be settled within the ensuing month.

Your obedient servant,

CHARLES K. GRAHAM,
Engineer-in-Chief.

The entire success of the "beton en masse system" on the Canal and King street sections had determined me to recommend to the Board its adoption for the future construction of Pier No. 1, it being my intention, if the suggestion was accepted, to substitute cribs formed of dock logs for the finished timber cribs, and to raise from them as platforms wet caissons, so that the employment of divers could be dispensed with except for the sole purpose of locating the cribs, the employment of divers in a current of at least three knots velocity, and in a depth of water, as the pier approaches its termination of nearly 50 feet, being a dangerous and profitless operation.

Moreover, I proposed to make the pier-head foundation of two parallel cribs, at right angles with the axis of the pier, connected by two parallel cribs longitudinally placed; to fill in the cribs only with concrete, and to place rubble in the centre. The adoption of these expedients and the reduction of the length of the pier to 425 feet, which had already been strongly advised by me for reasons which, in my judgment, are incontrovertible, would enable the pier to be completed, this year, at a saving of at least $100,000.

Christopher Street Section.

When this section was progressing I directed Mr. Radenhurst, Inspector of Engineering, to collect all data possible to show the utter inability of wooden bulkheads, located under similar conditions, to withstand the severe lateral pressure exerted by the immense mass of earth filling they would be compelled to sustain, without such excessive distortion as would render them entirely unsuitable for foundations upon which to construct any masonry wall, from low water up, intended to preserve a uniform alignment, free from unsightly openings and subsidences. The result of his labors is attached:

Memoranda.

Facts collected respecting the distortion of wooden bulkhead walls from lateral earth pressure.

No. of	Data furnished by	Position.	Effect of Distortion.	By whom built.
1	A. J. Murray.....	34th st. to 37th st., N. R.	12 to 14 feet, out irregularly.	G. White*
2	" "	38th st. to 40th st., " ..	About 7 " " " .	" "
3	" "	Jane st. to 12th st., " ..	" 7 " " " .	.....
4	" "	West 11th st , " ..	" 14 " " " .	.....
5	" "	35th st. to 38th st., E. R..	" 8 " from original line	B. Kelly.
6	" "	34th st. to 35th st., " ..	" 16 " " " "	Jenks.
7	" "	23d st. to 25th st., " ..	" 9 " " " "	.....
8	" "	11th st. to 13th st., " ..	" 15 " " " "	Kelly.
9	" "	96th st. to 100th st., " ..	" 9 " " " "	Earl.
10	" "	17th st., " ..	" 10 " " " "	Kelly.
11	J. Guthrie.....	30th st. to 33d st., " ..	" 2 to 14 feet, irregularly†	.....
12	W. N. Radenhurst	H. R. R. improvement, 65th st., N. R.....	Block gone irregularly some 3 or 4 feet, canting over at same time. The force of pressure not as yet felt.‡	

Memoranda.—Some facts stated by Assistant Superintendent Guthrie in relation to the building of wooden bulkheads around the city and its environs:

"The bulkheads deviate from original line principally from faulty construction; too rapid filling in of earth from shore end; sinking of cribs not properly balanced with stone; material consisting of short timber not properly bolted, and settlement of cribs to hard pan—after stone has been inserted.

"Piles have been driven *through* and *outside* of crib to prevent sagging outwards with success. Unskilled labor employed and inferior timber used."

The Hudson River Railroad Company on their work at Sixty-fifth street, North river, constructed during the summer a "tramway" on piles on a 2° curve, across the westerly end of "bayou," between Sixty-fourth and Sixty-third streets, North river. Previous to the construction of this "tramway" a great deal of dredged material, amounting to between fifty and sixty thousand cubic yards had been taken from the new bulkhead line, and deposited in the easterly end of the "bayou." The piles which formed the substructure of the "tramway," had been driven down to rock, having but little holding mud, but deemed by the engineer in charge sufficiently stable to serve all the purposes for which the tramway was intended.

* Immediately after making earth.

† A block 700 feet long deviated from original line to such a degree that piles had to be driven in front.

‡ Company are driving piles in rear.

The earlier part of this month the mud deposited in the rear slid with such a force as to carry away piles, lumber track, and a platform erected in the rear, making a total wreck of everything; the mud that had caused the disaster reappearing some fifty yards to the west of where the tramway stood, and showing about 2 feet above mean low water.

In May last I instructed Mr. Staats, Surveyor, to ascertain the position of the bulkhead placed by the Hudson River Railroad Company, opposite to their grounds on the Hudson river at the foot of Sixtieth street, with reference to the established bulkhead line of the Department, and he reported to me as follows:

"I find that the bulkhead just north of the northerly line of Sixtieth street, is now four feet seven inches west of the west bulkhead line; and at a point opposite the centre line of Sixty-first street, it is about fourteen feet west of department line. This difference is due to the manner in which the crib-work has been forced out or bulged, the versed sine at point of greatest curvature being nearly eleven feet."

The crib placed on the bulkhead line by the Hudson River Railroad Company is composed of dock logs, filled in with rubble, and at its base is forty-five feet wide; to mean low water it is forty-two feet six inches high; from this point to the level of the coping, twelve feet six inches, it is composed of square timber. The whole height from its base being fifty feet; the width at top thirty feet.

These facts establish conclusively that no structure, save and except a wall formed of either natural or artificial stone, properly founded on piles, has the capacity requisite to resist the lateral pressure to which it is subjected; and the wall already finished at Christopher street section having demonstrated that it possesses all the elements requisite for the solution of the problem, naught remains, except in future portions of the wall yet to be constructed, to reduce the mass of the material to the lowest practicable limit, to substitute "beton en masse" for manufactured blocks, and rubble facing with granite cope for the cut-granite facing heretofore used.

After the trench for the wall on this section had been completed, and three hundred feet of the wall erected, at ebb tide, a very perceptible current was developed, where hitherto slack water had prevailed, thus proving that when the wall is continuously built, and the open system of piers substituted for the block and bridge piers now existing, sufficient current will be created to sweep all sewerage matter toward the sea. This process will be rendered still more certain, however, if the sewer outlets are carried to the end of the piers, as is the ultimate intention when the Department of Works completes the new sewers rendered necessary by the widening of the river street. In anticipation of this last mentioned improvement, the Department of Docks should adopt some process for the thorough preservation of

the new timber piers, as simultaneously with the restoration of clear limpid water the *teredo navalis* will reappear.

The creation of this current is likewise an assurance that the widening of West street, from a varying width of from seventy to one hundred feet, to a uniform width of two hundred and fifty feet, bounded as it will be by an unbroken masonry bulkhead line, with open-pile piers projecting therefrom, will increase rather than decrease the cross section of the Hudson, as was feared by many advocates of the improvement when it was first suggested.

All the beton blocks used at this section were manufactured at the Gansevoort street yard, under the supervision of General Schuyler Hamilton, who likewise tested all the cement of which they were composed. The cement was the English Portland, of the brands of White Bros., and Knight, Bevans, and Sturge. The blocks were made on platforms in moulds, and generally remained at the yard for some months after they were completed, but in some few instances, when the work was being hurried, were transported to the points required and placed in position within ten days after they were finished.

Canal Street and Other Sections.

Since this report was written the Canal street section has been extended about two hundred feet, the short section at the foot of King street completed, and a new section commenced at the foot of Clarkson street. The plan of construction being in every case precisely similar, except on the Clarkson street section, where it has been deemed advisable, in consequence of the great depth and softness of the mud, to drive the two front rows of piles with a batir of one and three-fourth inches, instead of perpendicularly as on the other sections; the object of the change being to oppose still greater resistance on the part of the foundation to lateral pressure, and to enable the mould-boards to be slid down further, so that the concrete may bind the pile-heads to a greater depth.

On all these sections the cut-granite facing is adhered to, a large quantity of dressed granite being on hand in the Seventeenth street yard. It is probable, however, that when this stock is exhausted on sections yet to be constructed, the facing will be composed of rubble blocks made in the Department yards, and transferred by scows to the desired points and set by the ten-ton derrick.

On the King street section the concrete was mixed on board of scows and placed within the caisson by means of the ten-ton derrick, the bucket used having a capacity of two cubic yards.

The advantages of the beton *en masse* system are:

First.—As many sections as the Department deem advisable can be in course of construction at any one time, the distance between the old piers enabling the work to be prosecuted in the slips without any serious hindrance to commerce.

Second.—The work by the adoption of the heating process as applied to water, sand, and stone, may be prosecuted, at least, during nine months out of the twelve.

Third.—Unskilled labor can replace to a very great extent the skilled labor required under the block system.

Fourth.—The huge and expensive one-hundred-ton derrick can be dispensed with, and small scow derricks employed for lowering the concrete, and the ten-ton derrick for placing the granite masonry, and eventually the manufactured rubble blocks.

Fifth.—After the various sections of the wall in the slips are sufficiently advanced, by means of temporary approaches they can be connected with the old piers, thus allowing these old piers to be cut away on the line of the wall for the purpose of joining the adjacent sections. The outer ends of the old piers can be used as long as desirable.

Sixth.—The new piers being differently spaced from the old, these new piers may be projected from the new bulkhead wall and completed in a great many instances, before it becomes necessary to remove the old ones.

Seventh.—The rapidity with which the work may be prosecuted, and the immense saving in its cost.